REMARKS

The Office Action dated November 4, 2003, was a final rejection of claims 1, 12-17, 19 and 20 of the above-referenced patent application. Claims 2-11 and 18 were objected to as being dependent upon a rejected base claim.

The Applicant, however, believes that the application is in condition for allowance because each of the claims is novel and nonobvious over the cited art. The reasons for this belief in the novelty and nonobviousness of the rejected claims are presented below. The Applicant, therefore, respectfully requests further examination and reconsideration of the subject application.

Preliminary Observations

Prior to discussing the Applicant's claimed features that are lacking in Day et al., the Applicant wishes to point out some general overall differences between Day et al. and the Applicant's claimed invention. Namely, the Applicant's claimed invention includes a novel system and method of calibrating range cameras and the system and method disclosed in Day et al. is for determining the position and attitude of a three-dimensional body using conventional cameras. In order to calibrate these cameras, Day et al. use conventional calibration techniques.

Specifically, the Applicant's claimed invention includes "determining a relative pose of each camera (also known as *calibration*)" (specification, page 9, lines 15-16; emphasis added). This calibration includes the calibration of "range cameras, which are used to measure the 3-D structure of a scene, give the range (or depth) of each pixel. In order for two or more range cameras to work properly together, the system (such as a range imaging system) using the range cameras must be able to determine a relative position and orientation of each camera (specification, page 9, lines 10-15). Calibration of the range cameras "enables the system to convert 3-D measurements from each camera into a common coordinate frame. Data from each camera is in the camera's local coordinate frame, and calibration of each camera makes the 3-D measurements

from different cameras (in different local coordinate fram s) consistent with each other" (specification, page 9, lines 16-20).

On the other hand, the system and method of Day et al. is **not** a calibration system and method. Day et al. assumes that the relative locations of certain known points (such as target points or gauge holes) are known (see for example, col. 7, lines 29-30). Day et al. is used to automatically determine "the position and attitude of a three-dimensional body" using these known points (Abstract). A calibration module is provided in Day et al., but this calibration is different from calibration claimed by the Applicant. Namely, the calibration module 56 of Day et al. "obtains information about projections of the calibration fixture 34 into the individual camera image planes. This is done either manually or by having a robot bring a calibration objects into the field of view of the system cameras 26 and generating projection information" (col. 10, lines 8-13). FIG. 4 of Day et al. illustrates this calibration fixture 34.

Not only is the Applicant's claimed calibration technique different from that disclosed in Day et al., but the Applicant also expressly discusses the disadvantages of this type of calibration. Namely, the Applicant states that "[S]everal types of manual calibration techniques are used to calibrate the range cameras. One type of calibration technique uses a three-dimensional calibration chart to determine the relative position of each camera. This technique, however, is difficult to use and time-consuming because it requires that the calibration chart be positioned correctly within a scene" (specification, page 2, lines 15-20). Clearly the calibration fixture 34 of Day et al. is a three-dimensional chart that has the disadvantages discussed in the Applicant's specification.

Section 102(b) Rejections

The final Office Action rejected claims 1, 12-16, 19 and 20 under 35 U.S.C. § 102(b) as being anticipated by Day et al. (U.S. Patent No. 4,639,878). The Office Action stated that Day et al. disclose each and every element of the Applicant's claimed invention.

The Applicant respectfully disagrees with this contention. In general, the Applicant submits that Day et al. lack at least one feature of the Applicant's claimed invention. Even when the Applicant's claimed invention is given its broadest interpretation, Day et al. is missing several material features present in the Applicant's claimed invention.

Independent Claim 1

Independent claim 1 of the Applicant's claimed invention includes a method of determining a relative position and orientation between a base camera and a non-base camera. The method includes measuring a path of an object with the base camera in a base coordinate frame and measuring the object path with the non-base camera in a non-base coordinate frame. The method further includes calculating transformation parameters based on the object path, and applying the transformation parameters to the object path measured by the non-base camera such that the object path measured by the non-base camera is expressed in the base coordinate frame.

In contrast, with regard to independent claim 1, Day et al. do not disclose the following material claimed features of the Applicant's claimed invention:

1. "measuring a **path** of an object with a base camera":

In the Applicant's claimed invention, a path of an object is measured with a camera. The term "path" implies movement. In fact, the Applicant's specification makes this clear when, in reference to FIG. 2, the specification states that the "calibration of the range cameras 208, 216 generally is performed by having a person 288 (denoted by an "X") ***move in a path*** 296 around the room 256 (specification, page 11, lines 12-14; emphasis added). Moreover, given its plain meaning, the term "path" means "the continuous series of configurations that can be assumed in any motion or process of change by a moving or varying system" (Webster's Ninth New Collegiate Dictionary, page 862; emphasis added). In other words, an object path includes the movement of the object. The Applicant's claimed invention includes measuring this object movement using a base camera.

In contrast, Day et al. merely discloses "determining the **position** and attitude of a three-dimensional body in space" (col. 3, lines 55-58). No movement of the body is determined or measured; only position and attitude. The Examiner stated that Day et al. "shows 'measuring a path of an object with a base camera' in (Col. 3-4, lines 55-58)." However, as discussed below, the Applicant can find no disclosure in that section of Day et al. or in any other section of Day et al. that discloses the Applicant's claimed feature of using a camera to measure an object path. In particular, referring to FIGS. 1 and 2 in Day et al., no mention is made in Day et al. of the path of the automotive body 16 being measured by a camera, nor a robot path being measure by a camera, nor any other path being measured by a camera. Absent any further clarification by the Examiner, the Applicant is at a loss to understand and address the Examiner's reasoning with regard to this claimed feature of the Applicant's invention. The Applicant respectfully requests that the Examiner point out to the Applicant specific passages and wording in Day et al. that the Examiner believes anticipates this claimed feature.

The automotive body 16 of Day et al. is captured by cameras, but it is merely the position of known points on the body 16. These points do not move with respect to each other, and thus are **not** an "object path". Day et al. allow the body 16 to be grossly positioned at the work station and, by seeking out "several known features or targets on the body", can determine the position of the body in space (col. 5, lines 13-16). In other words, the body (or object) is grossly positioned within camera view and the vision system and method of Day et al. is used to determine the body's position in space. Unlike the Applicant's claimed invention, there is no need or disclosure in Day et al. of a camera measuring the body's path.

Day et al. also require that the relative locations of certain known points on the object be known. Namely, Day et al. describe using at "least three target points" and "generating a single plane of image data for each of the target points" (col. 4, lines 12-13 and col. 4, lines 15-16). The Day et al. invention uses "the gauge holes 24 as visual targets or target points" (col. 6, lines 46-47). The "gauge holes 24 are relatively invariant and are used as a baseline for all measurem nts. While the body 16 as a whole may be

somewhat non-rigid, th gauge holes 24 maintain a constant relationship with respect to each other" (col. 6, lines 41-45). Using these known points, only the position of the body 16 in space is determined, *not the path*.

The only path mentioned in Day et al. is a path of a robot. In particular, after gross positioning of the body 16, Day et al. uses path compensation for the robot to reprogram the robot's path based on the actual position of the vehicle body 16 (col. 4, lines 26-30). The "path compensation data relates to the difference between the actual and expected positions of the three-dimensional body at the work station" (col. 4, lines 30-33). Thus, the path described is the path of the robot 14.

The robot path in Day et al., however, is not captured by any of the cameras. As shown in FIG. 1 of Day et al., the robots 14 are behind the cameras, and out of each camera's field of view. The only requirement in Day et al. is that the known points on the body (i.e. gauge holes 24) "are disposed within the field of view of each of the cameras 26" (col. 6, lines 62-65). However, Day et al. neither discuss nor illustrate the robot path within the field of view of the cameras. Thus, the robot path **cannot** be measured by any of the cameras.

2. "measuring the object path with the non-base camera":

As argued above, Day et al. does not use any of the cameras to measure an object path. Furthermore, an object path is not measured by more than one camera. In the Applicant's claimed invention, the object path is measured by two cameras: a base camera and a non-base camera.

In contrast, Day et al. use one camera for each target point. The camera capturing the target point only has a single target point in its field-of-view. Specifically, "[A]s shown in FIG. 3, the vehicle body 16 can be thought of as a rigid body with three known target points (i.e. gauge holes 24), each of which is only visible to one of the cameras 26" (col. 7, lin s 28-31).

3. "calculating transformation parameters based on the object path":

In the Applicant's claimed invention, the object path measured by the two cameras is used to calculate transformation parameters.

In contrast, Day et al. do not calculate transformation parameters based on object path. As stated above, the only object path discussed in Day et al. is a robot path, and the robot path is not an object path measured by two cameras (or any cameras). More specifically, it is an object of Day et al. "to be able to determine the transformation [T] by looking at the target point in each camera's field of view" (col. 7, lines 62-65). As argued above, a target point is not an object path. Thus, Day et al. do not disclose this claimed feature of the Applicant's claimed invention.

Because Day et al. is missing at least the above three material claimed features of the Applicant's claimed invention, the §102 rejection of independent claim 1 cannot stand.

Independent Claim 19

Independent claim 19 of the Applicant's claimed invention includes a method of calibrating a first and a second range camera. The method includes measuring a path of an object with the first *range camera* to generate a first observed object path, and measuring the object path with the second range camera to generate a second observed object path. The method further includes calculating a transformation parameter that causes the first observed object path to approximately overlap with the second observed object path so as to determine a relative pose between the first and second range cameras.

In contrast, with regard to independent claim 19, Day et al. do not disclose the following material claimed features of the Applicant's claimed invention:

1. "measuring a path of an object with the first rang camera":

As argued above with respect to independent claim 1, Day et al. do not disclose using any of the cameras to measure a path of any object.

Further, Day et al. merely disclose using a conventional camera, **not** the Applicant's claimed range camera. In particular, the Applicant claims a range camera, which is "a device that is used to measure a 3-D structure of a scene by providing range (or depth) information as measured from a plane on the camera. Thus, while a black and white camera provides a grayscale intensity of each pixel and a color camera provides a color of each pixel, a range camera provides a range (or distance to the 3-D scene) of each pixel. Range cameras use a variety of techniques to measure range including lasers, projected light patterns and stereo vision" (specification, page 1, lines 25 to page 2, line 2).

In contract, Day et al. disclose using conventional cameras. Specifically, the cameras used in Day et al. "preferably comprise conventional CCD's which provide standard television output signals" (col. 6, lines 56-58). Unlike the Applicant's claimed range cameras, the conventional cameras of Day et al. provide no range information.

2. "measuring the object path with the second range camera":

As also argued above with respect to independent claim 1, Day et al. do not disclose measuring an object path with more than one range camera. In fact, no object path is measured. Day et al. merely disclose using one conventional camera to capture each target point (col. 7, lines 28-31). Thus, Day et al. do not disclose the Applicant's claimed feature of measuring the object path with the second range camera.

3. "calculating a transformation parameter that causes the first observed object path to approximately overlap with the second observed object path":

In the Applicant's claimed invention, a transformation parameter is calculated that causes the first observed object path (or the object path as observed by the first range camera) to approximately overlap with the second observed path (or the object path as observed by the second range camera) (specification, page 15, lines 3-15).

In contrast, Day et al. do not use any transformation parameters to cause object paths to overlap. As stated above, the only path discussed in Day et al. is a robot path. And nowhere do Day et al. discuss using a transformation to cause the robot paths to overlap. Thus, Day et al. do not disclose the Applicant's claimed feature of calculating a transformation parameter that causes the first observed object path to approximately overlap with the second observed object path.

Because Day et al. is missing at least the three material claimed features of the Applicant's claimed invention noted above, the §102 rejection of independent claim 19 cannot stand.

Independent Claim 12

Independent claim 12 of the Applicant's claimed invention includes a method of measuring a relative pose between two cameras. The method includes selecting a time offset value corresponding to a time shift between the two cameras, and calculating a transformation parameter using the time offset value, the transformation parameter capable of transforming data in a coordinate frame of one of the two cameras into a coordinate frame of the other of the two cameras so as to obtain the relative pose.

In contrast, with regard to independent claim 12, Day et al. do not disclose the following material claimed features of the Applicant's claimed invention:

1. "selecting a **time** offset value corresponding to a **time shift** between the two cameras":

In the Applicant's claimed invention, a time offset value is added to the data. This time offset value is based on **time**. The time offset is added to solve the problem of clocks on separate computers used to sample the data being unsynchronized by a constant time offset (specification, page 16, lines 5-8). In other words, the time offset value corresponds to a time shift between two cameras. In effect, this time offset value synchronizes the two cameras.

In contrast, Day et al. merely disclos a **position offset**. More specifically, in Day et al. position offsets are used to by robots "which are able to use the offsets to compensate their taught paths for the rigid body currently being worked upon" (col. 10, lines 60-63). In other words, the robot path is adjusted by the position offset amount to ensure that the robot is in the correct position with respect to the vehicle body 16. Thus, in contrast to the Applicant's claimed invention that includes a time offset value (or temporal offset), Day et al. merely disclose a position offset (or spatial offset).

2. "calculating a transformation parameter using the time offset value":

In the Applicant's claimed invention, a transformation parameter is calculated using the time offset value.

In contrast, Day et al. do not calculate a transformation based on a time offset value. As stated above, Day et al. merely determines a "transformation [T] by looking at the target point in each camera's field of view" (col. 7, lines 62-65). Thus, Day et al. do not disclose the Applicant's claimed feature of calculating a transformation parameter using the time offset value.

Because Day et al. is missing at least the above two material claimed features of the Applicant's claimed invention, the §102 rejection of independent claim 12 cannot stand.

Because the Applicant's claimed invention includes numerous material claimed features neither taught, disclosed nor suggested by Day et al., the Applicant respectfully submits that the rejections of independent claims 1, 12 and19 under 35 U.S.C. § 102(b) as being anticipated by Day et al. has been overcome based on the arguments set forth above and below. Moreover, rejected claims 13-16 depend from independent claim 12 and rejected claim 20 depends from independent claim 19 and therefore also are novel over Day et al. (MPEP § 2143.03). The Applicant, therefore, respectfully requests reexamination, reconsideration and withdrawal of the rejection of claims 1, 12-16, 19

and 20 under 35 U.S.C. § 102(b) as being anticipated by Day et al. based on the arguments above and below.

Section 103(a) Rejection

The Office Action rejected claim 17 under 35 U.S.C. § 103(a) as being unpatentable over Day et al. in view of Huang et al. (U.S. Patent No. 4,945,493).

The Office Action contended that the combination of Day et al. teach all the elements of the Applicant's claimed invention, except for teaching the use of a least squares solution. However, the Office Action stated that Huang et al. disclose the "use of a least squares solution in order to solve simultaneous equations to have a result quickly."

In response, the Applicant respectfully traverses this rejection based on the following legal and technical analysis. In general, the Applicant submits that the combination of Day et al. and Huang et al. are lacking numerous elements of the Applicant's claimed invention. In particular, the combination does not disclose, either explicitly or implicitly, at numerous claimed features and fails to appreciate the advantages of these claimed features. Thus, the Applicant submits that the combination of Day et al. and Huang et al. cannot make obvious the Applicant's claimed invention.

To make a prima facie showing of obviousness, all of the claimed features of an Applicant's invention must be considered, especially when they are missing from the prior art. If a claimed feature is not disclosed in the prior art and has advantages not appreciated by the prior art, then no prima facie showing of obviousness has been made. The Federal Circuit Court has held that it was an error not to distinguish claims over a combination of prior art references where a material limitation in the claimed system and its purpose was not taught therein. *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988). Moreover, as stated in the MPEP, if a prior art reference does not disclose, suggest or provide any motivation for at least one claimed feature of an Applicant's invention, then a prima facie case of obviousness has not been established (MPEP §

2142).

Independent Claim 12

As argued above, Day et al. lack at least the following features of the Applicant's claimed invention:

1. "selecting a time offset value corresponding to a time shift between the two cameras"; and

2. "calculating a transformation parameter using the time offset value".

The combination of Day et al. and Huang et al. also lacks these features. Specifically, Huang et al. merely disclose path offsets (i.e. spatial offsets) (col. 3, lines 63-67). These offsets are different from the Applicant's claimed time offset value. Moreover, Huang et al. nowhere discusses using a time offset value to calculate a transformation parameter. Thus, the combination of Day et al. and Huang et al. lacks at least the above two features of the Applicant's claimed invention.

The combination of Day et al. and Huang et al. also fails to appreciate or recognize the advantages of the Applicant's claimed time offset value. More specifically, this feature alleviates the problem of clocks on separate computers used for data collection being unsynchronized (specification, page 16, lines 4-9). The combination of Day et al. and Huang et al. fails to discuss or appreciate these advantages.

The Applicant, therefore, submits that obviousness cannot be established since the combination of Day et al. and Huang et al. lacks at least two material claimed features of the Applicant's invention. Namely, the claimed features of "selecting a time offset value corresponding to a time shift between the two cameras", and "calculating a transformation parameter using the time offset value" are not taught by this combination. In addition to explicitly lacking these features, the combination also fails to implicitly disclose these features. In particular, the combination lacks any suggestion and fails to provide any motivation for the Applicant's claimed features. Further, the

combination fails to appreciate advantages of th se claimed features. Therefore, as set forth in *In re Fine* and MPEP § 2142, the combination of Day et al. and Huang et al. cannot render the Applicant's claimed invention obvious. Consequently, because a prima facie case of obviousness cannot be established due to the lack of "some teaching, suggestion, or incentive", the rejection must be withdrawn. MPEP 2143.01; ACS Hospital Systems, Inc. v. Montefiore Hospital, 732 F.2d 1572, 1577, 221 USPQ 929, 933 (Fed. Cir. 1984).

Accordingly, the Applicant respectfully submits that independent claim 12 is patentable under 35 U.S.C. § 103(a) over Day et al. in view of Huang et al. based on the legal and technical arguments set forth above and below. Moreover, claim 17 depends from independent claim 12 and also is nonobvious over this combination (MPEP § 2143.03). The Applicant, therefore, respectfully requests reexamination, reconsideration and withdrawal of the rejection of claim 17 under 35 U.S.C. § 103(a) as being unpatentable over Day et al. in view of Huang et al..

Claim Objections

The Office objected to claims 2-11 and 18 as being dependent on a rejected base claim. However, the Office Action stated that these claims would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

In response, the Applicant notes that the base claim for claims 2-11 is independent claim 1 and the base claim for claim 18 is independent claim 12. As argued above, both independent claims 1 and 12 are patentable over the cited art.

Conclusion

In view of the arguments set forth above the Applicant submits that claims 1-20 of the subject application are in immediate condition for allowance. The Examiner, therefore, is respectfully requested to withdraw the outstanding rejections and objections of claims 1-20 and to pass each of th claims to issue.

In an effort to expedite and further the prosecution of the subject application, the Applicant kindly invites the Examiner to telephone the Applicant's attorney at (805) 278-8855 if the Examiner has any comments, questions or concerns, wishes to discuss any aspect of the prosecution of this application, or desires any degree of clarification of this response.

Respectfully submitted,
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